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Title: **ISR Reach-Back: A Human-Systems Integration Assessment from Trident Warrior 2004**

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Abstract

During Trident Warrior 2004, a net-centric initiative was evaluated for demonstrating reach-back Image, Surveillance, and Reconnaissance (ISR) video exploitation. Specifically, the initiative examined the concept of remote, but timely, support provided by a small team of extremely capable personnel. While information, in the form of images, was successfully pushed from the reach-back facility to the afloat forces, and all technical requirements were met, a number of problems were identified with the process. There are important issues the lie beyond technical connectivity. Enabling proactive actions at a reach-back facility requires achieving shared situation awareness, which in turn requires effectively addressing the procedural and cognitive requirements for supporting shared situation awareness. Human-System Integration can play a prominent role in defining and guiding this solution.

Introduction

During Trident Warrior 2004, a net-centric initiative was evaluated for demonstrating reach-back/reach-in Image, Surveillance, and Reconnaissance (ISR) exploitation of unmanned aerial vehicle video. The initiative was to demonstrate receipt of unmanned aerial vehicle (UAV) video at an ashore node for exploitation and then publication of decision-quality products to the Expeditionary Strike Group (ESG). The initiative examined the concept of remote, but timely, support provided by a small team of extremely capable personnel to minimize manning while maintaining the operational tempo and battle rhythm. This net-centric concept examined whether ESG supporting/supported nodes could share all relevant information while being physically separated. This net-centric concept requires effective shared situation awareness for ISR. Shared situation awareness for ISR, in turn, consists of two major elements: (1) a way for both the ashore and afloat sites to view a common and consistent battlespace display (ideally through a common database), combined with persistent and constant communications links (collaboration tools to facilitate interaction), and (2) the ability to pass intelligence information between the reach-back facility and the afloat site. This report focuses on a Human-Systems Integration (HSI) evaluation of the reach-back ISR initiative. For a full description of the Trident Warrior 2004 analysis see Naval Postgraduate School (2005).

ISR entails a coordinated effort to identify, validate, and verify a potential target for fire. The ISR process consists of seven major steps that occur in response to a Request For Information (RFI).

1. **Assignment** - Receipt of the RFI along with any clarifying or constraining information about the mission it supports and how the ISR products will be used.
2. **Collection** - Creation and execution of a plan to collect information related to the RFI.
3. **Processing** - Translation of collected information into man or machine readable formats. Evaluation of the suitability and quality of the collected information, and assignment and prioritization of the resources required to exploit that information.
4. **Exploitation** - Review of the RFI and the collection process, identification and annotation of Elements of Essential Information (EEI) in the collected information, and identification and annotation of other items of potential interest.
5. **Analysis/Fusion** - Fusion of all exploited information sources with other intelligence related to the RFI and mission. Creation of reports and other ISR products based on analysis of the fused intelligence.

6. **Dissemination** - Includes routing ISR products to recipients and storage of images and reports in database(s).
7. **Management** - ISR process monitoring, support, and modification.

Trident Warrior is the major FORCEnet Sea Trial experiment sponsored by Naval Network Warfare Command (NETWARCOM). It focuses on network-centric warfare to improve tactical situation awareness in order to accomplish two main purposes. First, it aims to provide "Speed to Capability," a rapid fielding of improved FORCEnet command and control warfighting capability to the Fleet with full supportability and maintainability. Second, it develops supporting tactics, techniques, and procedures which are intended to optimize the use of new technologies for the execution of naval operations.

Trident Warrior 2004 (TW04) was conducted on 4–15 October 2004 in the Southern California Operating Area. It employed USS Tarawa (LHA 1) Expeditionary Strike Group (ESG) and supporting platforms executing a Fleet Response Plan deployment to the CENTCOM Area of Responsibility. TW04 provided an opportunity to collect actual performance data in a realistic field setting during simulated combat operations. In TW04, HSI addressed the relationship between human users and FORCEnet technologies in order to promote effective and efficient mission performance.

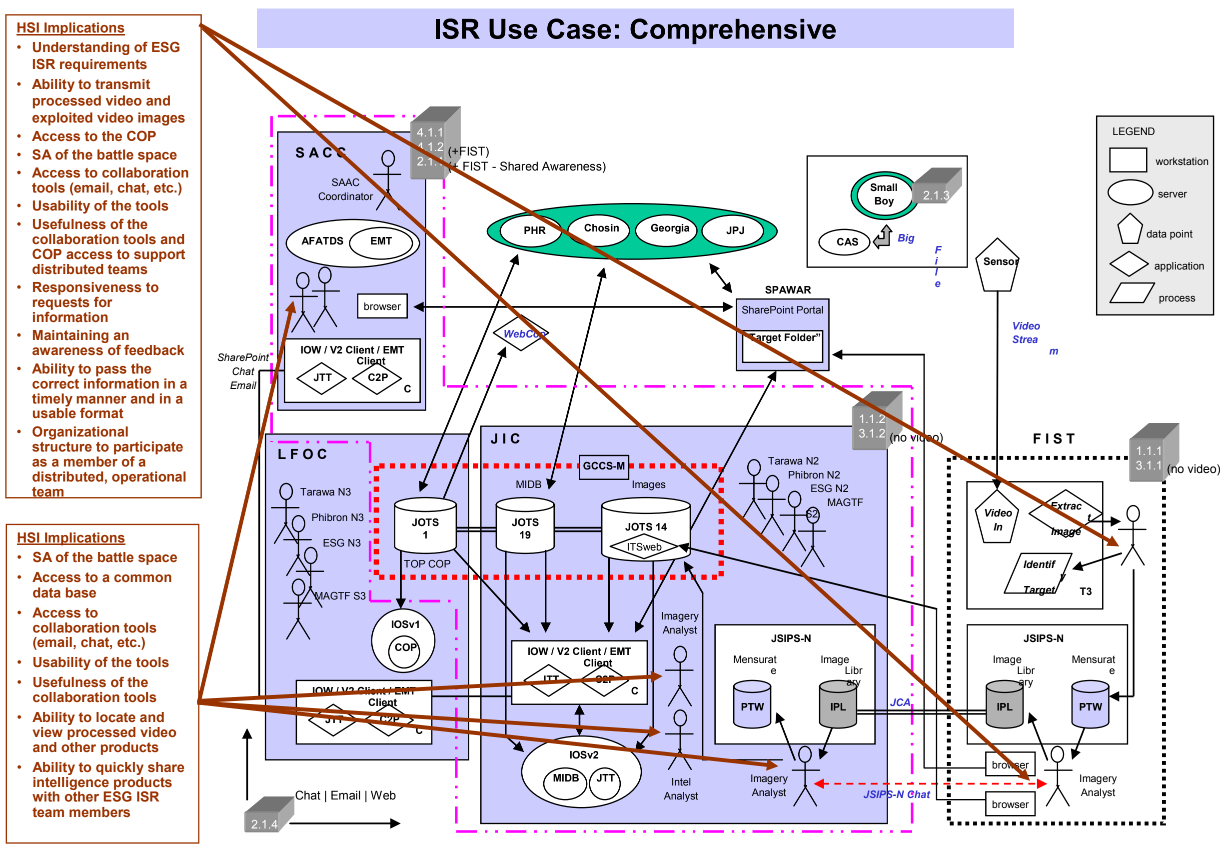

Figure 1. Detailed view of the distribution of ISR functions to locations and their organizational relationships during TW04. In particular, the Joint Information Center (JIC, bottom center area) and Supporting Arms Coordination Center (SACC, upper left area) resided aboard the ESG while the image exploitation function, the Fleet Intelligence Support Team (FIST, lower right area), resided ashore. RFIs are sent from the JIC to the FIST. Video is exploited in the FIST and returned to the JIC and the SACC.

To achieve its objectives for target identification, validation, and verification, ISR requires the coordinated use of the following technologies: WebCOP, HITS, JSIPS-N, AFATDS, SACC-A, and BFT.

- **WebCOP (Web Common Operational Picture)**. WebCOP is a Web-based Geographic Information System (GIS) that aggregates disparate data from various sources and plots them on an interactive world map that may be viewed in a standard web browser. In addition to allowing the location symbology of mapped data items to be displayed, WebCOP also supports user queries for detailed information about the mapped data. Data item collections, or layers, may be individually displayed and hidden by users until the desired operation picture is created.
- **HITS (Hostile Forces Integrated Targeting System)**. HITS allows users to locate and share targeting information between ships using existing communications channels.
- **JSIPS-N (Joint Service Imagery Processing System – Navy).** JSIPS-N is a shipboard digital imagery system with the capability to receive, process, exploit, store, and disseminate imagery products and imagery derived intelligence reports based upon multi-source imagery from national and tactical sensors. The primary purpose of JSIPS-N is to increase the self-sufficiency afloat of tactical aviators and strike, naval fire support and expeditionary force planners in the precision delivery of ordnance.
- **AFATDS (Advanced Field Artillery Tactical Data System).** AFATDS automates fire support C2 planning and coordination of all supporting arms for Army/Marine Corps missions. It is the primary means of planning, coordination and execution of Joint Fires for JTF WARNET.
- **SACC-A (Supporting Arms Coordination Center – Automated).** SACC-A space on TARAWA is located adjacent to ship's CIC. The space and installed equipment is the Navy's initial fielding of an automated network centric fire support cell. Fire support, by its nature, is a distributed process. Digital interfaces between fire support systems and other systems, especially maneuver and intelligence, are critical enablers. Aboard ship, the ISNS SECRET GENSER LAN is the primary conduit for automated information exchange.
- **BFT (Blue Force Tracking).** BFT focuses on improved battlespace situational awareness via location information of friendly combat forces. BFT is a significant requirement that arose from Operation Iraqi Freedom.

For TW04, only the technical connectivity was attempted and assessed. The plans did call for both reach-back and afloat sites to view and reference the common operational picture via WebCOP, but the unavailability of WebCOP prevented this. As a fall-back alternative, chat and e-mail were used to establish and maintain communications between the afloat and ashore sites. A full suite of collaboration tools was not installed on the exploitation workstation that would have facilitated effective communication. Due to this deficiency, third party, rather than direct, communication was used between exploiters. This approach requires a greater amount of time and involves inferring the intent of the sender.

Originally, the plan was for a surrogate UAV to fly, its video would be exploited at the shore node (Fleet Intelligence Support Team – FIST), and then the exploited intelligence information would be disseminated to the Tarawa Joint Intelligence Center (JIC). The primary means for accomplishing this task was the Joint Services Imagery Processing System – Navy (JSIPS-N) Concentrator Architecture (JCA) to the JSIPS-N Image Product Library (IPL). Alternative means involved using the Imagery Transfer Services (ITS) Web to the JOTS-14 (Global Command and Control – Maritime [GCCS-M] imagery server), or using the web to place a shared Target Folder in a Space and Naval Warfare Command (SPAWAR) SharePoint Portal. Chat and e-mail were used to understand what had been done and when in order to support the afloat ISR needs.

Due to poor weather during the first week of TW04, the surrogate UAV flights were delayed and the video captured was of poor quality. Since evaluation of the ISR initiative concerned the ability of Tarawa to receive exploited imagery and video information, archive imagery and pre-recorded video were used until the second week of the TW04 exercise, when live video of good quality was transmitted from the surrogate UAV to the FIST. SIPRNET was sporadic at the outset of TW04 and did not become reliable until late in the week, so chat and e-mail were correspondingly affected. Due to time zone differences, there was a limited period to establish the real time connectivity needed for coordination of tasks. Even for systems of record, FIST had to obtain the IP address and receive permissions to post a file to the Tarawa IPL. The Tarawa JSIPS-N operator pulled a posted image into the Precision Target Workstation + (PTW+) in order to push it to the JOTS-14. Using ITS Web, Marine intelligence analysts and SACC analysts would pull from JOTS-14. In order to pull imagery, the puller needs to know how and where it was saved in the database (product name, folder, etc.). Close coordination was required among all nodes to establish the procedures and standards for posting and retrieving imagery from the various databases. These requirements initially delayed sharing the intelligence that was being generated.

Method

Twenty-three participants in the ISR and Fires scenario responded to the HSI questionnaire. These participants were located in either the FIST (7 respondents), the JIC (13 respondents) or the SACC (3 respondents). These participants were observed during the ISR and Fires scenario, and they filled out detailed questionnaires following the scenario. The scenario examined issues involved in communication, collaboration, and coordination among afloat and shore resources in planning and executing a Fires scenario. The creation, processing, and transmission of images based on UAV video was a central aspect of this scenario.

Naval reserve personnel and human factors professionals served as on-site data collectors ("ship riders") during TW04. They were responsible for collecting all non-automated HSI exercise data, which included completing all data collection instruments (questionnaires, interview forms, observer checklists). HSI observers were responsible for collecting data during the test scenarios via observer logs, interviews, and checklists and for assuring that questionnaires were completed by participants following each scenario. In addition, HSI observers collected data concerning system usability and workspace layout issues.

The Program Offices provided operator training on the TW04 technologies to all ship personnel and ESG staff who were available prior to the exercise. Unfortunately, many of the watchstanders did not receive this training and entered the exercise with little or no familiarity with the technologies. On-site support and training from technical representatives helped moderate this problem. However, the knowledge gaps experienced during the first several days of testing adversely impacted the quality of the HSI data collected.

Another significant difficulty for collecting quantitative human performance data in TW04 resulted from the lack of an orientation briefing for the watchstanders prior to most of the tactical scenarios. Without this background on track locations and situational issues, which is typically gained in a watch turnover briefing, the watchstanders had to spend a substantial portion of the scenario acquiring this situation awareness. Many of the scenarios in the later portion of TW04 were preceded by this kind of information.

Considering that many of the FORCEnet technologies were installed as temporary additions to the ships' configurations, the placement of these systems was adequate to support TW04 HSI testing. While many of the workspaces needed redesign to better accommodate the staff and all of the supporting technology, TW04 systems were generally accessible and placed near the personnel who needed to use them.

The ships were underway during TW04 and, therefore, had various real-world issues and work schedules to deal with concurrently. Nevertheless, there was minimal distraction from other duties, fatigue, and other environmental issues.

Results

Overall, the technical objectives of the ISR reach-back task were achieved, but a number of issues were raised about all stages of the reach-back process. While requests for information were successfully passed back from the JIC to the FIST and exploited images were successfully passed forward from the FIST to the JIC, timeliness of reporting was a problem, and real-time target information was not passed. Overall systems usability and workload was mediocre and mental workload was moderate. Scores on the System Usability Scale (DEC, 1986) at the JIC, FIST, and SACC fell in the mid 50s out of a possible 100. By comparison, the highest rated systems during the exercise, the NITES meteorological system and a remote broadcast system achieved usability scores in the 80s and the lowest score during the exercise was 42. Mental workload, based on the NASA Task Load Index or TLX (NASA, no date) reached a score of 3.8 out of 7 for fires systems in the JIC and a low of 2.8 for reach-back systems in the FIST. These scores indicate that the ISR reach-back technologies required a moderate level of mental exertion by users.

Next, we delve into each aspect of the reach-back ISR process. The first step in the process is to convey a request for image exploitation. This request should be efficient to compose in the JIC and efficient to understand in the FIST. Users in the FIST rated their understanding of what information was needed by the JIC as 3.5 out of 5. This moderate level of understanding developed from both a common operational picture (COP) and collaborative exchanges. For TW04, the COP was to be conveyed by the WebCOP system, but this system was not available for technical reasons. This outage led to significant limitations on sharing the operational picture. In particular, personnel in the FIST were not aware of the status of blue forces outside of the Trident Warrior exercise.

Without WebCOP, users fell back on other systems including chat and e-mail exchanges. This fallback system did not lead to an effective COP. FIST personnel rated their understanding of the operational picture as 2.9 out of 5. Extended chat and e-mail exchanges (15-50 text exchanges regarding some issues) improved the users' COP for specific issues and periods of time, but the length of these longer exchanges suggests large inefficiencies in this method of collaboration. Nonetheless, when available, chat and e-mail were used successfully to transmit and receive information. Chat and e-mail were given a rating of 3.6 out of 5 by personnel in the JIC for conveying COP information. This level of understanding permitted proactive actions on some occasions. However, chat, e-mail, and telephone connectivity over the SIPRNET was spotty throughout TW04, which limited even this method of collaboration. Due to this spottiness, the overall ratings of these technologies for meeting users' needs for exchanging tactical information fell to 2.9 out of 5. Further still, chat exchanges were often conveyed through third parties, for technical connectivity reasons, which limited both timeliness and clarity of interpretation.

This spotty connectivity and COP led to an interesting difference in users' estimations of how well their own team's understanding of the tactical situation matched other teams' understanding. Personnel in the SACC rated their mutual understanding as a 3.0 out of 5 while personnel in the FIST rated their mutual understanding as a 2.0 out of 5. This difference illustrates how individual users with relatively good situation awareness may come to believe that all other teams share their situation awareness. Remotely located teams, however, may in fact have reduced situation awareness due to limitations on connectivity and the common operating picture.

In addition to a common operating picture, it can be important for forward and reach-back teams to understand each others' tasking, at least to the degree it affects the understanding of requests, priorities, and image exploitation requirements. During collaborative exchanges, personnel in the FIST rated their understand of their collaborators' tasking as a 3.0 out of 5. Overall, however, personnel in the FIST rated their ability to keep track of other teams' activities as a 2.0 out of 5, and personnel in the SACC rated their ability as a 2.7 out of 5.

The next step in the reach-back ISR process is to exploit the images. During TW04, images were retrieved from a UAV to the FIST for exploitation. Overall, personnel in the FIST believed that the exploited images sent from the FIST to the JIC did not provide adequate tactical information for targeting decisions and that further exploitation of the images by the afloat team would be needed. FIST personnel rated the information content of the sent images as a 2.8 out of 5. They rated the products sent to the JIC as being detailed enough to be useful for targeting as a 1.3 out of 5, clear enough for targeting as a 1.5 out of 5, and satisfactory enough for ESG intelligence needs as a 2.1 out of 5. Opinions among FIST personnel varied widely on these ratings. This variation may have been due to differences in the specific images each person viewed, or it may have been due to different understandings of the needs of the JIC based on the variable quality of the COP available at the FIST.

In large measure, these low ratings appeared to be due to the low quality, low timeliness, and low level of detail provided by the UAV images received at the FIST. FIST personnel rated the quality of the UAV images as a 1.3 out of 5, timeliness as a 1.3 out of 5, and level of detail as a 1.1 out of 5. FIST personnel did not find the images easy to assess (1.7 out of 5) or easy to understand (2.0 out of 5). Overall, FIST personnel rated their satisfaction with the UAV video provided to them as a 1.3 out of 5. One explanation for the low quality of the video was poor weather during the exercise, but the timeliness and difficulty of access ratings suggest that additional problems may be involved.

The third step in the reach-back ISR process is transferring the exploited images from the FIST to the JIC and then on to the SACC. Three areas of concern were identified. First, SIPRNET outages made it difficult to perform some transfers, and there were several links in the transfer process which raised transfer failure rates: FIST to CIPL to IPL to Tarawa IPL. However, transfer from the JIC to the SACC was more timely and satisfactory, rated by JIC personnel as a 4.0 out of 5. A second area of concern was due to differences and confusion about file formats. Only some formats were readable afloat. Therefore, some successfully transferred files could not be read. Poor collaboration connectivity between the ashore and afloat sites undoubtedly exacerbated this problem. The third area of concern was a lack of established procedures for posting images, both in terms of locations and naming schemes. At times, personnel had difficulty determining which images had been transferred and where to look for them.

It seems likely that a large part of the problems encountered in transferring files from the shore facility to the afloat staff was due to difficulties integrating databases and systems across services. As these issues are addressed and procedures established, much of these transfer problems will recede. However, it is important to note these problems so that they receive the attention they require.

Discussion

Assessment was complicated by bad weather, which constrained many of the planned UAV flights, and by the unavailability of the WebCOP communication link. Backup collaboration tools, such as chat and e-mail were frequently interrupted and generally not entirely sufficient for maintaining quality shared situation awareness and timely collaboration. These technical issues aside, a number of usability problems were noted relating to the coordination of databases, imagery locations, formats, and access permissions. The availability of WebCOP in future exercises, resolving these business rule and usability issues, and achieving higher communication link reliabilities should substantially improve ISR shared situation awareness. Improved shared situation awareness, in turn, should promote enhanced video exploitation and usability.

Various problems were experienced in exchanging information between the FIST and the JIC, although most of these were eventually overcome during TW04. Reliable network access, well understood work processes, and understanding of the commander's intelligence needs are key to effective and efficient participation by reach-back assets. SACC personnel were able to access necessary targeting information from the JIC in a timely manner. Problems involving operator mental workload and the usability of several of the technologies were noted, and these should be addressed as a way to improve overall targeting performance. Further consideration of the work process and design for rapid response planning, rather than pre-planned strikes, may be necessary and may result in significant reductions in mental workload and increases in performance.

ISR systems had moderate usability for distributed and reach-back operations. Incompatible versions of software between Tarawa and FIST added considerable response time to transfer images of acceptable quality. Other usability problems, such as creating target folders, should also be addressed. Reach-back and forward deployed systems need to be interoperable and integrated to assure complete and timely access to ISR information. The JIC and SACC were able to collaborate effectively on intelligence information and to transfer information efficiently and quickly. Network reliability was cited as a significant problem, however. The collaboration tools available to JIC personnel were limited to chat and email and were considered to provide only moderate utility and usability. Improvements in the collaborative tool suite are needed to facilitate information transfer and intelligence support for planning and operational processes.

Conclusions

While information, in the form of images, was successfully pushed from the reach-back facility to the afloat forces, and all technical requirements were met, a number of problems were identified with the process. The issue is how to establish and maintain a shared understanding of the battlespace among two distributed sites, one being remote from the ongoing tactical situation. If afloat forces are going to rely on reach-back for intelligence resources, several aspects of this process need to be addressed:

- **Shared situation awareness of the operational context and the intelligence needs at the afloat site**. Individual situation awareness within the battlespace is dependent on the individual's role within the situation. Shared situation awareness, which is critical for effective distributed environments, depends upon the development of a shared understanding of what is necessary for individuals to reach their own, and the group's, goals. For the reach-back facility, this shared understanding means being fully cognizant of the ESG commander's intent as well as the commander's information requirements. Without this understanding, the reach-back component might still be able to provide reactive support, but it certainly would not be able to provide proactive support.

- **Proactive vs. reactive support**. If the reach-back asset is going to play a major role as part of the ISR team, it will have to go beyond the reactive mode and provide more proactive support where it anticipates the needs within the ESG tactical situation and initiates tasks and provides intelligence products before the ESG commander requests them.

- **ESG commander "ownership" over the reach-back asset**. A major concern of command and control is the recognition of lines of authority and the need to respond in a timely and effective manner within those lines. If an ESG asset is not physically present within the ESG, it is not necessarily a problem. However, it may prove problematic to have an asset that the ESG may not be able to control during critical operational events.

- **Physical proximity to the tactical situation**. This issue considers the stress of being actively involved in a tactical situation. Staff at a site that is physically remote from the tactical situation, may have difficulty understanding the time constraints for initiating and completing ESG tasking. It is possible that at least some staff at a reach-back site will not have the forward deployed experience that is needed to draw accurate inferences from tasking received or to place information provided in an appropriate context. Both the organizational structure of a reach-back facility and the experiences of its staff can affect the performance of the ISR tasks supporting the ESG.

All of these issues appear to be quite solvable. As the points above describe, however, there are important issues the lie beyond technical connectivity. We believe the ultimate solution to these issues in performing reach-back ISR tasks is more a matter of understanding the interrelationships between tasking and cognition and supporting shared situation awareness among the afloat and ashore teams. Enabling proactive actions at a reach-back facility requires achieving shared situation awareness, which in turn requires effectively addressing the procedural and cognitive requirements for supporting shared situation awareness. Once this awareness is acquired, reach-back products can be generated that are proactive and responsive to changing task requirements, tactical constraints, and operating environments. Human-systems integration can play a prominent role in achieving improved shared situation awareness by determining the procedural requirements and usability characteristics of the involved technologies needed to acquire and maintain situation awareness among physically dispersed teams.

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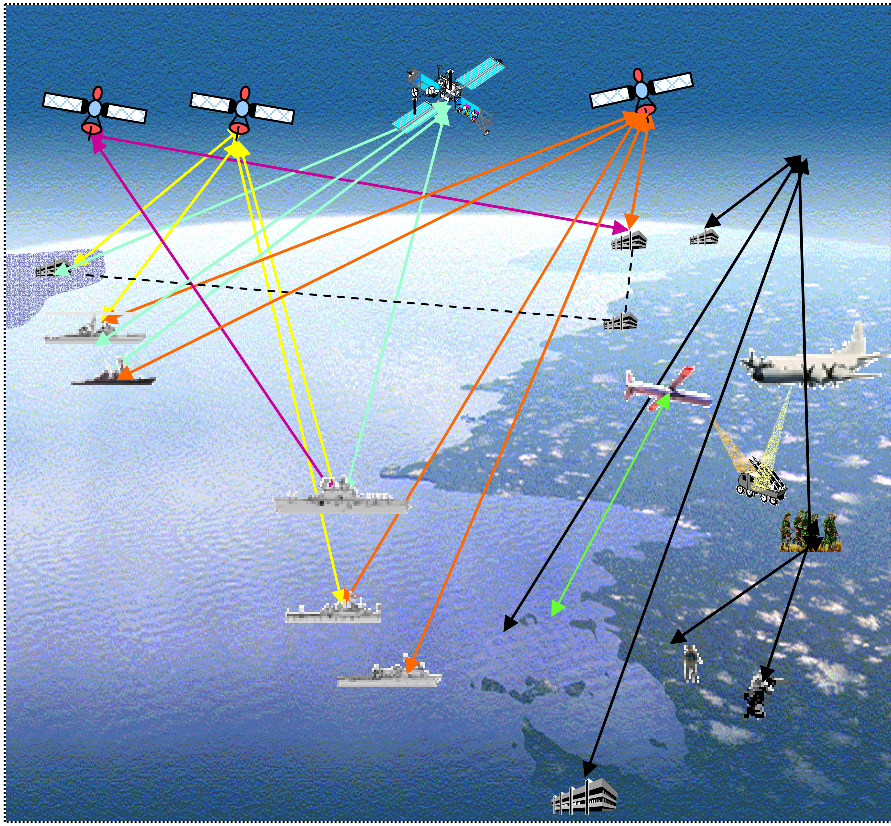
ISR Reach-Back

An HSI Assessment from TW04



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FORCEnet Concept

Command and control component of Sea Power 21

Designed to enhance commanders' tactical situation awareness and decision making abilities

Definition: the operational construct and architectural framework for naval warfare in the Information Age, integrating warriors, sensors, command and control, platforms, and weapons into a networked, distributed combat force.

– CNO

ISR Reach-Back

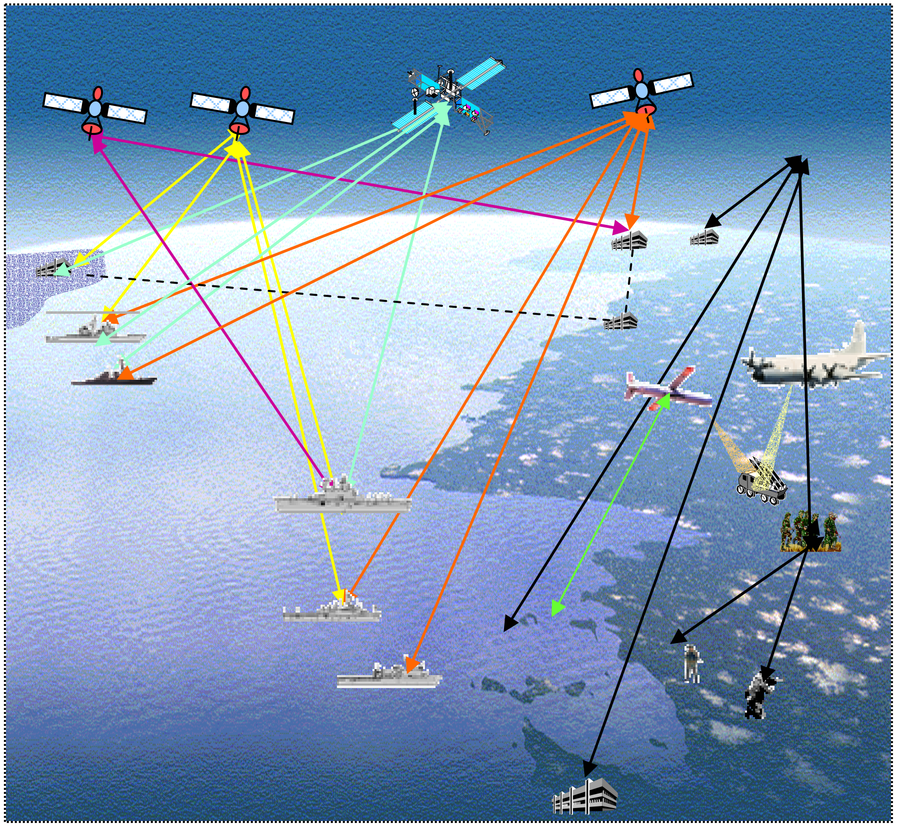
Goal

- Video exploitation for targeting via a remote (ashore) facility

Process

- Request for information
- Assignment
- Collection
- Processing
- Exploitation
- Analysis/Fusion
- Dissemination
- Management

Ashore



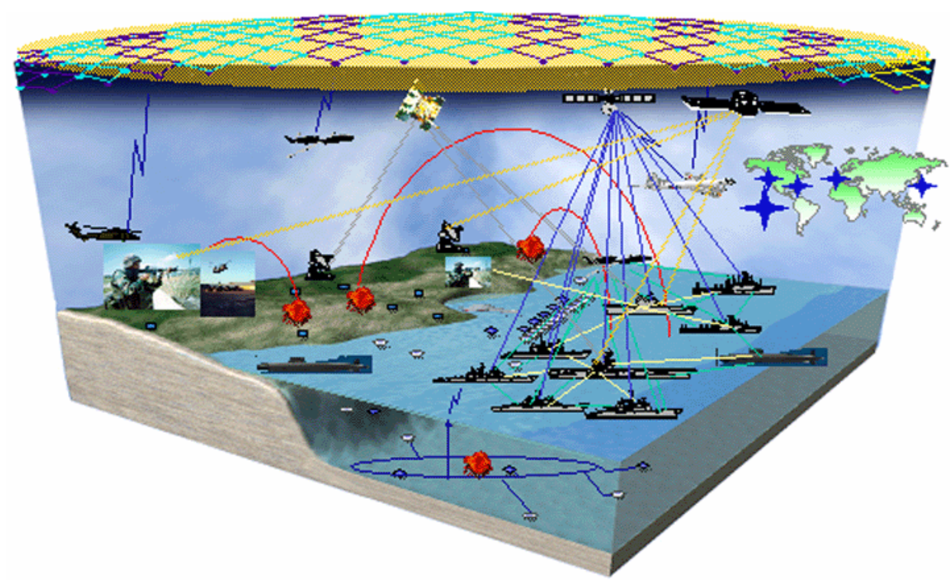
Trident Warrior Sea Trials

Trident Warrior

- Assess and implement FORCEnet systems
- Focus on network-centric warfare to improve tactical situation awareness
  - Rapidly field improved FORCEnet command and control warfighting capability to the Fleet
  - Develop supporting tactics, techniques, and procedures

Trident Warrior 2004 (TW04)

- 4–15 October 2004
- Southern California operating theater



ISR Reach-Back in TW04

Afloat-Ashore functional distribution

- Afloat (Tarawa ESG)
  - Joint Information Center
  - Supporting Arms Coordination Center
- Ashore (FIST)
  - Fleet Intelligence Support Team
- Technologies
  - WebCOP, HITS, JSIPS-N, AFATDS, SACC-A, BFT

HSI evaluation

- Effectiveness
- Usability
- Scientific guidance on “how to get there”

Evaluation Procedures

Participants

- 13 from JIC
- 3 from SACC
- 7 from FIST

Data Collection

- ISR/Fires scenarios
- Questionnaires
- Focused interviews
- Observer checklists
- Automated logs

Fleet exercise constraints

- Variable training on technologies
- Variable orientation briefings
- Poor weather
- Sporadic connectivity
- Unavailable Common Operating Picture technology (WebCOP)

Overall Results

Technical objectives were achieved

- RFIs passed
- Exploited images passed

Usability mediocre

- Mid 50s out of 100
- Other systems high of 80s and low of 40s

Mental workload moderate

- 3-4 out of 7

In-Depth Evaluation

- ★ Request for information
- Assignment
- Collection
- Processing
- ★ Exploitation
- Analysis/Fusion
- ★ Dissemination
- Management

Request For Information (to FIST)

Understand request

- 3.5 out of 5

Understand COP

- 2.9 out of 5

Use of chat

- Extended chat exchanges – 15-50 exchanges on some issues
- Chat/email effectiveness: 2.9 - 3.6 out of 5

Poor “remote” understanding

- SACC (afloat) COP: 3.0 out of 5
- FIST (ashore) COP: 2.0 out of 5

Image Exploitation (in FIST)

Effectiveness

- Information content: 2.8 out of 5
- Sufficient detail for targeting: 1.3 out of 5
- Sufficient for ESG intelligence: 2.1 out of 5

Factors

- High variability
  - Specific images
  - Variable COP
- Low image quality, timeliness, detail
- Difficult access: 1.7 out of 5

Dissemination (to JIC)

Connectivity

- Sporadic
- Multiple links in chain

File formats

- Some unreadable afloat

Transfer procedures

- Locations
- Naming conventions
- Feedback

Database integration

Summary – HSI Concerns

Poor shared SA technologies

- No WebCOP
- Chat/Email sporadic
- Chat/Email “sparse”

Poor information management

- Databases
- Compatibilities
- Business rules

Caveats

- Poor weather
- Insufficient training
- Leading edge technologies

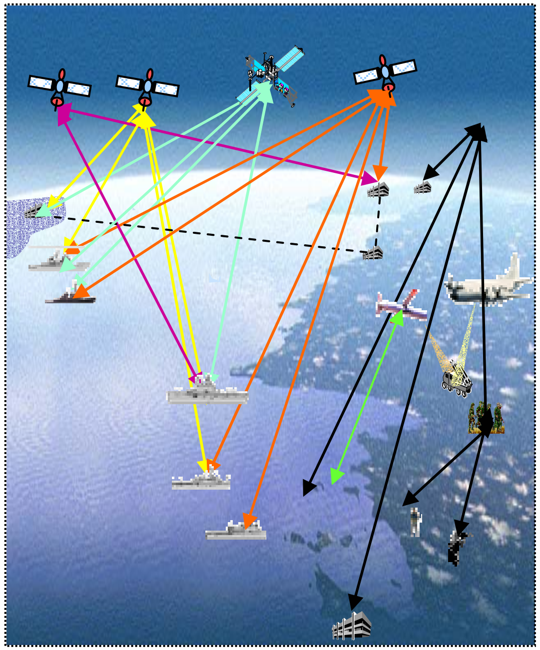
HSI Recommendations

Distributed information management of images and analyses

- Effective, transparent business rules
- The Devil is in the details

Shared situation awareness

- Commander's intent
- Commander's information requirements
- Proximity to tactical situation – battle rhythm
- Proactive support
- Common Operating Picture
  - Good COP, Bad COP
- Team SA



Robust, integrated communications

- Beyond connectivity – integrated with COP

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